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# Location-based Services: A Roadmap for New Zealand

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## Abstract

The advancement in mobile, wireless and positioning technologies have enabled applications and services such as route guiding and emergency call-out assistance. These and other similar services have become known as 'location-based services' (LBS). The literature on LBS development and deployment addresses technological issues (for example, usability and integration) and issues related to LBS implementation – including LBS adoption and user privacy protection, and LBS business models. In this paper, LBS development and deployment are studied from a global perspective and the New Zealand LBS landscape is explored and analysed. It is suggested that legislation, technology and business strategies are the main universal drivers of LBS development. In New Zealand, the regulatory environment emerges as the most significant critical success factor (including emergency call location and a competitive service provider market).

*Keywords*: Mobile services, location-based services, location-aware services, LBS, location value, New Zealand, LBS reference model, LBS roadmap, case study.

## 1 Introduction

Location-based services (LBS) which integrate wireless technology, positioning technology, and location information management, have a significant potential to improve existing services such as emergency ones or to offer new services such as tourist guidance, and thus to open new revenue streams for LBS providers (Docter, et al. 2007, Fritsch, and Scherner, 2005, Antikainen, et al. 2006, Koutsiouris, et al. 2007). Examples of applications where LBS have been successfully deployed include mobile emergency calls, fleet management, mobile yellow pages, and route finding.

The development of new LBS applications is a complex and challenging task which involves a range of information and communications technologies (ICT). It needs to be based on an appropriate business model meeting the requirements of the potential user market, and needs to take into account the regulatory environment in the deployment area. Subsequently, current research in the area of LBS is focused on business modes and user issues (e.g. user privacy, service usability), and on LBS applications and enabling technologies.

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Based on a literature review of works exploring LBS in the context of a country (e.g. Japan, USA), or a geopolitical entity (e.g. the European Union - EU), this paper attempts to analyse the global LBS landscape including technologies, services, applications, and legislation, and to identify the positioning of New Zealand with respect to LBS development. The focus of the study is on the factors driving LBS adoption, on the issues emerging from LBS implementation, and on their implications.

The paper is organized as follows: The next section provides background information, introduces an LBS reference model, and formulates the research objective of the study. The sections following describe the methodology used, present the findings and analyse their implications. The last section outlines the limitations of the study, briefly summarises the paper and formulates suggestions for the development of LBS in New Zealand.

## 2 Background and Methodology

LBS are related both to more traditional services such as the Global Positioning System (GPS) which is a satellite positioning technology enabling the location of people and objects, and to well known applications such as Geographic Information Systems (GIS) which include databases populated with spatial location data. Contemporary LBS are also known as 'location –aware services', 'wireless location services', 'mobile location services' and can be viewed from different perspectives, including mobile telecommunication systems, location-aware technologies, handheld mobile devices, and applications (Shiode, Li, Batty, Longley, and Maguire 2002). Following (Virrantaus, et al. 2001) and (Schiller, and Voisard 2004), for the purposes of this paper LBS are defined as applications which provide a mobile user with an information service related to and dependent on the location of the user. The scope of LBS considered here is limited to 'outdoor' LBS where the positioning process may use either the mobile network, or the handheld device, or both in determining the user location.

### 2.1 Reference Model

Adapting the mobile commerce reference framework proposed in (Petrova, 2005), a reference model for outdoor LBS can be derived (Figure 1). Similarly to other mobile commerce applications, in the case of LBS the bottom layer (*Infrastructure*) comprises supporting technologies. However the handheld device in the infrastructure layer may need to have a positioning capability (usually a mobile phone or a PDA) depending on the technology used for positioning. The *Interface* layer includes a positioning component which is specific for LBS: A *positioning process* is needed to obtain and process location information and determine the mobile customer's position. The top layer (*Business*) includes mobile service provision (processing a user request for location-dependent information), and mobile application content provision (sourcing and maintaining the data needed to satisfy the request). The business model is designed to bring 'location value' to the mobile user or customer through the provision of a service dependent on their geographic location at the time of the request..

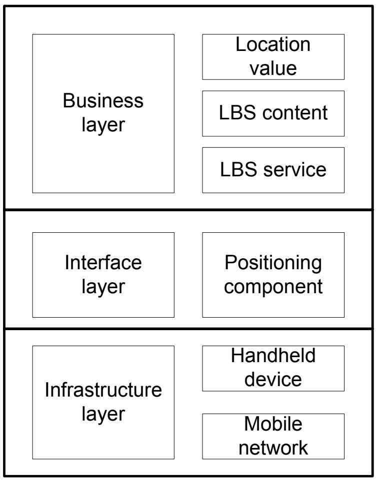


**Figure 1: LBS reference model**

### 2.1.1 Positioning Component

For outdoor environments, the positioning process normally uses either the GPS infrastructure or the mobile telecommunication network. Currently, a number of technologies are used (Figure 2). The network-based ones (Cell-ID, Enhanced Cell ID - ECID, Angle of Arrival - AOA, Time Difference of Arrival - TDOA) use mobile network data to determine the user position, while handset based technologies such as GPS use a satellite positioning system. The satellite positioning system is totally independent of the mobile network. Hybrid technologies (Enhanced Observed Time Difference – E-OTD, Assisted GPS - A-GPS) use both approaches. It needs to be noted that some technologies are relatively expensive and require line–of-sight (AOA, TDOA), while others may require significant handset modifications (ECID, GPS, E-OTD, A-GPS) (Unni, and Harmon 2003).

### 2.1.2 Location Value

According to their type and from a customer perspective LBS can be classified as: *Emergency*, *Navigation*, *Information*, (or *Infotainment* -- including entertainment, travel information, and directory assistance), *Advertising*, *Tracking*, and *Billing* (Schiller, and Voisard 2004, Steiniger, et al. 2006, Giaglis, et al. 2003, Yunos, and Gao 2003, Mennecke and Strander 2003, Kalakota, and Robinson 2002, Vasileios, et al. 2003).

The location value component generated and brought to the customer by a specific LBS depends not only on the business model but on the underpinning enabling technologies and the infrastructure. Location value contributes to the perceived quality of the service and determines the effectiveness of the respective business model. It is therefore important to be able to apply a measure to the location value. For example, the accuracy of the positioning and the quality of the location dependent content can be used as a measure of the location value (Figure 2).

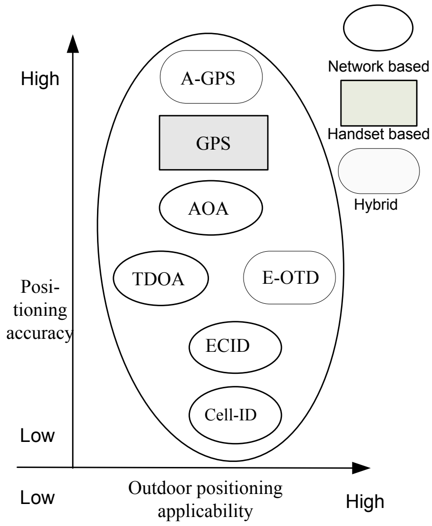


**Figure 2: LBS positioning technologies**

Services based on A-GPS such as providing directions (a navigation service) and routing emergency calls (an emergency service) are the most accurate and would be expected to be the most valuable. Services based on TDOA/OTD (lower accuracy technologies ) such as traffic management and travel services (navigation services), personnel tracking (tracking), and mobile searchable directories (information) are less valuable as the positioning component is less accurate. Cell-ID services (e.g. location –sensitive billing, vehicle tracking) are among the least valuable services.

### 2.1.3 Issues Related to Location Value

The literature review allows to identify a number of issues related to the quality of LBS which may be able to impact negatively on location value and thus become detrimental factors to LBS adoption.

*Issues at the Infrastructure and Interface Layers: Reliability, Time, Interoperability*. As discussed, positioning accuracy can be used as a measure of location value. Coupled with accuracy is the reliability of the derived location information, which similarly to accuracy is highest for A-GPS based services (Mohapatra, and Suma 2005). However the time taken to determine the position may become an issue as it normally will be reversely proportional to the accuracy and reliability (DTI Global Watch Service 2004).

Finally, as an LBS may involve more than one mobile network operator, of particular concern are LBS scenarios where mobile networks are using different positioning technologies.

*Issues at the Business Layer: Information Currency, User Privacy.* The currency of the information retrieved in response to a location dependent request also affects the location value brought to the customer. Location-sensitive information (e.g. travel and routing information) can change very often, so keeping the LBS content up-to-date is essential for the quality of the service.

Another important issue for users receiving personalized location based information is location privacy: in addition to the need to keep user location information confidential, it is also necessary to prevent users from being illegally tracked (Dao, et al. 2002). To this effect, in some countries legislation such as general data protection acts provide a level of user privacy protection (Adusei, et al. 2004). A slightly different issue is the one of the legality of using location data (e.g. when monitoring a child's or an elderly person's activities). Such use may result in possibly illegal, or unethical restriction of the subject's activities (Perusco, and Michael 2007).

## 2.2 Methodology

As mentioned research in the area of LBS has its main focus on the issues identified in the previous section , i.e. technology, supporting platforms, business applications and social issues (Trevisani, and Vitaletti 2004, Gelllersen et al. 2002, Vasileios, et al. 2003, Shiow-Yang, and Kun-Ta 2006, Heinonen, and Pura 2006, Steinfield 2004, Peppard, and Rylander 2006, Docter, et al. 2007, Perusco, and Michael 2007, Ackerman, Kempf, and Miki 2003, Jorns, et al. 2007, Boondao, et al. 2003, Kaasinen 2003, Yunos, and Gao 2003, Ragia, and Deriaz 2006, Hinze, and Osborne 2007, Koutsiouris, et al. 2007).

With respect to New Zealand, a number of studies focus specifically on the potential and opportunities offered by LBS services in tourism (Berger et al. 2003, Hinze, and Buchanan 2005, Leung 2006, Parsons 2005). However no overall investigation of LBS development and related issues in New Zealand, and the factors that may influence LBS deployment and adoption has been reported so far.

The study presented here is based on the premise that a scholarly investigation of the current LBS landscape might provide useful insights and inform future research and development in the area. Furthermore, the results might also indicate future areas of ICT skill and capability development for academic institutions and programmes as the LBS industry segment gathers momentum and creates demand for highly specialised graduates with knowledge of mobile networking, mobile middleware, and location-based application development.

The primary objective of this paper is to derive an explanatory model for the LBS development and to provide recommendations to the relevant ICT industry stakeholders, academics and researchers. The following question guides the work: In what areas does New Zealand exhibit significant differences compared to developed countries where LBS are currently more advanced?

A multiple case study approach was chosen as a research strategy, as especially suitable for the exploration, classification, and hypothesis development stages of the knowledge building process (Benbasat, et al. 1987). Data collection was carried through a literature and document survey. The sources include published academic research, industry reports, and miscellaneous publications such as s newspaper articles and white papers. Apart from New Zealand, the three other data collection units are the USA, Japan, and the EU.

There are several reasons for this selection. In all three data units LBS have undergone extensive development over the past decade, with a range of applications available. For example, advanced technologies such as GPS have been used for some LBS in the USA; where the local legislative environment has contributed significantly to their development. The other developed country included - Japan is considered by many as the most advanced country in terms of overall LBS adoption; a large body of Japan-based or Japan-oriented research literature already exists. Finally, the EU is an active promoter of the GSM technology, which at present is the most popular mobile system standard and accounts for 82% of the global mobile market (GSM Association 2007).

The analysis of the data is conducted in three stages. First the data collected for each case are examined and summarized. This involves identifying the types of LBS, the service and application scope, the mobile technologies, and the mobile network market (operators and regulations). Secondly,) is used to Secondly, the outcomes of the findings are analysis and used to compare the case of New Zealand to the three other cases. Finally, a model mapping LBS development is proposed and used to draw conclusions addressing the guiding question of the study, formulated earlier.

# 3 Findings

This section presents in a summarised format the findings form each data collection unit, applying the LBS reference model and addressing the location value related issues highlighted in section 2.1.3. The applicable features of the regulatory environment are used to provide a case-specific background.

## 3.1 The Case of the USA

### 3.1.1 Regulatory Environment

In 1966, new legislation was introduced aimed at improving emergency call services, known as 'Enhanced 911' (E911). Mobile operators are obliged to provide automatically the caller's location information in a 911 emergency call situation. The E911 specifies the required levels of accuracy and reliability: for 67% of calls the returned location should be within 50 (or 100 meters) of the true location (for handset based and network based positioning respectively), and within 300 meters for 95% percent of the all calls. The compliance deadline was extended to 2005 (Federal Communications Commission, 2001). The E911 legislation has determined to a significant extent the choice of the positioning technology (Wilde, et al. 2004, Kerton, and Kerton 2003).

### 3.1.2 Infrastructure and Interface Layers

A relatively small number of wireless carriers / operators dominate the wireless carriers mobile network market place (among them Verizon Wireless, Cingular, Sprint Nextel). The technologies deployed support LBS (Maxon, 2005). Non GPS-compatible handsets are gradually phased out (Verizon, 2007). Third party business partners provide additional location-based services (e.g. Rand McNally). LBS are reliable and accurate due to the compliance with the E911 legislation.

The positioning technologies used are almost without exception A-GPS and U-TDOA (Uplink-Time Difference of Arrival) (Wilde, et al. 2004). The networks are highly interoperable as there are only two dominant positioning technologies.

### 3.1.3 Business Layer

Services provided include emergency, navigation, information, and tracking. LBS development and market penetration was positively influenced by the E911 legislation. All top three wireless carries offer commercial LBS (route discovery, navigation, directions, maps, fleet management, field management, people finder, property management). Applications are developed to provide static as well as dynamic (i.e. current) information. Growth in LBS is predicted to reach 1.1 million subscribed devices by the end of 2010. New applications continue to emerge, for example the location-enabled enterprise, and public sector LBS (In-Stat, 2006).

## 3.2 The Case of the EU

### 3.2.1 Regulatory Environment

In 2002 the EU Commission passed Article 26, a directive on universal service and users' rights relating to electronic communication networks and services. Members of the EU were asked to develop national regulations to enforce the automatic positioning of emergency calls and the subsequent routing to the single emergency call number 112 (E112). No positioning accuracy level and no implementation deadline were specified (European Commission 2003).

### 3.2.2 Infrastructure and Interface Layers

The dominant technology at the network layer is GSM. However there is a very large number of mobile and wireless operators across EU member countries, which may have different telecommunication standards. E112 requirements can be met by several different positioning technologies (Cell-ID, U-TDOA, A-GPS, E-OTD), however A-GPS emerges as the most preferred technology due to its accuracy and reliability. .

### 3.2.3 Business Layer

According to the literature, all service groups across the LBS spectrum are currently offered, including location based discount billing. LBS development initially was driven by customer demand. A number of applications offer dynamic content (Koutsiouris, et al. 2007). Predicted growth in 2010 is 18 million LBS users (Berg Insight 2006), with almost 50% of them using navigation services.

## 3.3 The Case of Japan

### 3.3.1 Regulatory Environment

In 2004 Japan's Internal Affairs and Communications Ministry started working towards the "The Emergency Location Reporting System". The system automatically notifies the call's location when a call from a 3G mobile telephone / IP phone is made to one of the emergency numbers. Location data is provided by GPS for GPS-enabled devices. For other types of handsets, location is derived from base station information (Ministry of Internal Affairs and Communications 2007). The service was set to start as of April 1, 2007, to be gradually expanded nationwide.

### 3.3.2 Infrastructure and Interface Layers

The two biggest wireless operators are NTT DoCoMo and KDDI, which run both 2G and 3G networks. The positioning technologies are respectively Cell-ID and A-GSM, i. e. location data accuracy is subject to variation (Srivastava, and Kodate 2004).

### 3.3.3 Business Layer

LBS on offer cover the whole range of business applications. Customers interact with integrated portals such as i-Mode (DoCoMo) and NaviWalk (KDDI). Even though the initial LBS development driver was technology, the successful business model of i-Mode generated strong customer demand. Distinct business models have been developed for three application deployment categories: carrier-hosted applications, mobile-station hosed applications, and application services provider hosted applications. The use of dynamic content is relatively high (Kamil, and Ellen 2003).

## 3.4 The Case of New Zealand

### 3.4.1 Regulatory Environment

At present there is no legislation regulating the servicing of emergency calls placed from devices connected to the mobile telecommunication networks, or legislation addressing the privacy of location information and the conditions of its use.

### 3.4.2 Infrastructure and Interface Layers

Two operators currently dominate the mobile market (Vodafone New Zealand and Telecom Mobile), with a partnership between Vodafone and TelstraClear to resell mobile offerings (Budde 2006, TelstraClear 2007). Literature sources indicate that Vodafone among the operators, Vodafone only deploys a primary location technology (Cell-ID) which would be able to support at least some LBS (Vodafone NZ 2007).

### 3.4.3 Business Layer

At present, only a few location-based services are available. Vodafone provides SmartFind - a subset service of Vodafone Live for 2.5G and 3G networks. SmartFind has a well-developed range of searchable locations including community features such as schools, libraries, and businesses (Cappel 2005). Both Vodafone and Telecom provide fleet management to businesses, using an additional GPS device (Telecom NZ 2007, Mrhawk 2007).

## 4 Analysis and Discussion

A comparison of the findings presented in the previous section allows to investigate further the guiding question formulated earlier. An analysis of the differences between New Zealand and the other three geopolitical entities and a roadmap for LBS development are presented below.

### 4.1 What Makes New Zealand Different?

#### 4.1.1 LBS Regulatory Environment

Generally LBS related legislation focuses on two issues. - the use of LBS for public safety and protection (e.g. emergency caller location), and the protection of personal privacy and rights. The USA, Japan and the EU have already legislated for mobile emergency services. With regard to legislation regarding location information privacy, there is some already in place in the EU and Japan (Ackermann et al 2003). In New Zealand there are no regulatory requirements with respect to providing location information in case of an emergency, and no specific LBS related privacy protection legislation.

#### 4.1.2 Positioning Technology

While in the USA, Japan and the EU highly accurate and reliable positioning technologies have been already adopted, in New Zealand only one of the major mobile network operators has some positioning capacity (Cell-ID). However Cell-ID is at the lower end of the scale in terms of accuracy and reliability (Figure 2).

#### 4.1.3 Available LBS

The spectrum of LBS offerings in New Zealand is relatively limited. A prohibitive factor may be the inadequate provisioning of location information by the networks which may mean that all services requiring positioning would need an additional third party device and thus be costly and inconvenient to customers.

#### 4.1.4 LBS/Application Content

The most common LBS applications in New Zealand are the "Yellow Pages" directory, and fleet management – both based on static GIS information. Dynamic content such as real-time traffic information (used for navigation), is not provided yet.

### 4.2 A Roadmap for LBS Development

Four LBS development determinants emerge from the analysis above: i) the wireless / mobile infrastructure, ii) the positioning technology, iii) LBS and application content, and iv) the regulatory environment. Using these determinants to define the definitive phases in LBS development, a general roadmap for LBS development can be charted as shown in Table 1. It consist of three phases .

In phase one, LBS are *possible*. The mobile network infrastructure lacks positioning ability, location accuracy is within the 300 metre range, the infrastructure cannot provide positioning independently of the handheld device. Services are based on static location information, there is a lack of dynamic content.

When phase two is reached, LBS become *feasible*. Accuracy improves to a range of 20- 200 metres, the infrastructure is capable of providing independent positioning, services include applications which return mostly static but also some dynamic (GIS-based) information which offers location value to customers, legislation is in place to drive the improvement of LBS.

In phase three, LBS become *viable*. The well-established positioning network infrastructure has very high accuracy (within 20-50 metres), provides transparent interoperability and positioning, applications can handle dynamic content, and offer precise location dependent information in real time. The location value proposition made to customers is very strong, and appropriate legislation exists both to drive improvement and to protect customers. User demand for the highly differentiated LBS exhibits a growth trend.

**Table 1: LBS development roadmap**

| Determinant | Phase 1: *LBS "possible"* | Phase 2: *LBS "feasible"* | Phase 3: *LBS "viable"* |
|---|---|---|---|
| Infra-structure | Not inter-operable, possibly many operators | Interoperable, possibly a hierarchy of operators in place | Interoperable even if many operators |
| Positioning | Limited capability | Significant capability, high accuracy | High-end technologies, very high accuracy and reliability |
| LBS and application content | Static content, a few services | A range of services with a mix of mostly static/dynamic content | Service range expanding, static and dynamic content offered as required |
| Regulatory environment | No specific legislation | Some specific legislation (emergency services) | Specific legislation to cover all aspects (emergency services, privacy, rights) |

The analysis suggests that at present the USA, Japan and the EU have already reached phase two of the roadmap model. Driven by both legislation and customer demand, the LBS market there is moving towards phase three, developing innovative applications. New Zealand however has reached only the initial phase one and its progress to phase two will depend on future developments in the areas of the four roadmap model determinants.

## 5 Conclusion

Applying the proposed LBS reference model , this paper presents a detailed picture of the current LBS landscape across a selection of countries and regions. Findings from documentary sources were analysed and a roadmap model for LBS development was created.

It was found that in the USA the regulatory legislation enforcing emergency call location played a major role as a driver of advanced positioning technologies adoption and commercial LBS/applications development. In Japan and in the EU, the regulatory environment also played a strong accelerating role.

With respect to technology, in Japan and in Europe the relatively cheap Cell –ID is widely used and allows more diverse customer oriented services to be provided, without necessarily adopting more reliable and accurate but also costly technologies.

The analysis showed that using location value to leverage revenue drives business models across all studied cases especially in the competitive environments of Japan and Europe (Peppard, and Rylander 2006, Kaasinen 2003).

Although the study has some limitations - its scope is limited to four data collection units, and only secondary data were used, it is hoped that the analysis presented earlier and the concluding comments below will be of interest to both ICT practitioners and academics.

Two major conclusions can be made. First , there is a gap between New Zealand and the most advanced countries in the deployment of LBS and related applications: as there is a demonstrated lack of significant LBS, with available positioning technologies lacking sufficient accuracy. Secondly, while at present the gap is 'one phase behind', it may increase in the future if the current trends in New Zealand prevail.

What could boost LBS development in New Zealand? Two possible key drivers emerge: Similarly to Japan and the EU, one of the drivers may be the industry demand for navigation and routing services from sectors such as tourism (Statistics New Zealand 2006, Ministry of Tourism 2007, Leung 2006). The second driver (similar to the USA) may be the public safety demand for emergency call location regulation.

New Zealand may be able to benefit from already tested technologies such as A-GPS. However in 2006 only about 20% of Telecom's 1.88 million mobile phones were A-GPS capable, with an even lesser percentage of Vodafone mobile phones (Schwarz, 2006).

Upgrading the positioning network infrastructure will be also costly. In the USA the government provided financial aid to operators' investing in upgrading in order to comply with E119 (Kerton, and Kerton 2003). However technological advances may help decrease the cost of upgrading.

The low population density in New Zealand may be a disadvantage as the three other cases considered are representing much more populated areas.

Finally the limited number of mobile operators in New Zealand, and the relative lack of strong regulations has led to a high termination fee market environment. As a consequence the revenues of the operators are driven mostly by voice traffic, with not enough incentives to invest further in mobile data applications (Kaspar 2006).

In summary, regulative legislation is likely to be the most important factor that could influence positively LBS development in New Zealand in the future, if it stimulated competition among mobile telecommunication companies and enforced the provision of user location data in the case of emergency calls.

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